

MOTOR-CAR MECHANICS FOR BEGINNERS.

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MOTOR-CAR MECHANICS FOR BEGINNERS;

AN A B C OF AUTOMOBILE
CONSTRUCTION.

WITH EXPLANATORY DIAGRAMS.

BY

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INTRODUCTION.

THE title of MOTOR-CAR MECHANICS sufficiently indicates the aim and object with which this little book was written; and I hope that by treating the subject in a manner at once simple in language and elementary in technical expression, that I have succeeded in placing before the mere beginner a knowledge of automobile anatomy in such form that he cannot fail to understand the construction and uses of the various parts which make up a complete motor-car.

G. F. P.

MOTOR-CAR MECHANICS FOR BEGINNERS.

No. I.—THE MOTOR.

THERE is a very considerable number of people interested in motor-cars who, for want of special training, have practically no knowledge whatever of the propelling machinery of this class of vehicle, and, as a consequence, debar themselves from the pleasures of motoring because the thing mechanical appeals to them as being quite beyond the comprehension of anyone but an engineer. They feel that if they own a car they must of necessity employ, at a high wage, a competent mechanic to look after it, without whom no journey can be attempted, and who will be, in every sense of the word, master of the situation. Quite naturally, this feeling tends to prevent many a man from purchasing a car. I hope, however, by treating the subject from an absolutely elementary point of view, to make it clear that, so far from a motor-car being a complicated piece of machinery on wheels, it is really not only very simple, but that any man of ordinary intelligence can so easily understand its principles that he will realise motoring is no more difficult than driving horses, and I can assure anyone who has not yet tried it that just as much sympathy may exist between an automobilist and

his car as between the driver of horses and his favourite animal, especially if the owner of the car knows a little more about its mechanism than is

just sufficient to enable him to steer straight and pull the speed levers.

I shall deal only with the petrol car, for the reason that this is the type which is largely in the majority, and for that reason information in regard to it will be of use to the greatest number of people. Such cars may be said roughly to be composed or made up of three parts: First, the motor, with its ignition apparatus, water-cooling and lubricating arrangements; second, the transmission gear,

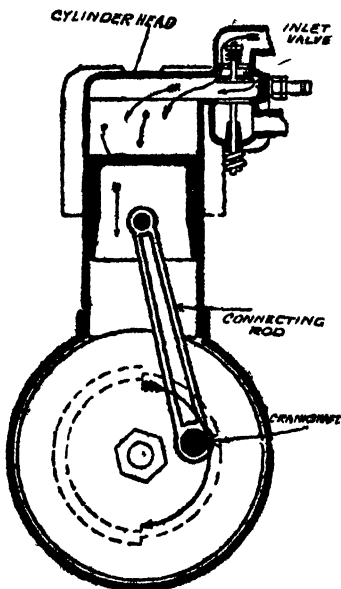


Fig. 1.—SUCTION STROKE.

by which the variations of speed and power are obtained; third, the *chassis*, in which is included the frame, brakes, wheels, axles, tyres, and steering gear.

One of the first things a novice is inclined to ask is, What do you mean by a "petrol car?" (which

is the general manner of describing the type of vehicle we are dealing with in contradistinction to a steam car). Petrol is the name which has been given to a light spirit obtained from petroleum oil, by distillation. That it is extremely light will be seen from the fact that, when taking the specific gravity of water at 60 deg. as 1, the specific gravity of petrol at the same temperature is $\cdot 680$. The quality which makes it so useful in motor-car engines is the fact that it is very volatile and evaporates easily, giving off a vapour which, when mixed with a correct proportion of ordinary atmospheric air, and after being compressed inside the cylinder of the motor, produces a highly explosive combination, which can be ignited by means of a small electric spark, the resultant expansion of the gases producing the power required to drive the piston. It is for the purpose of obtaining

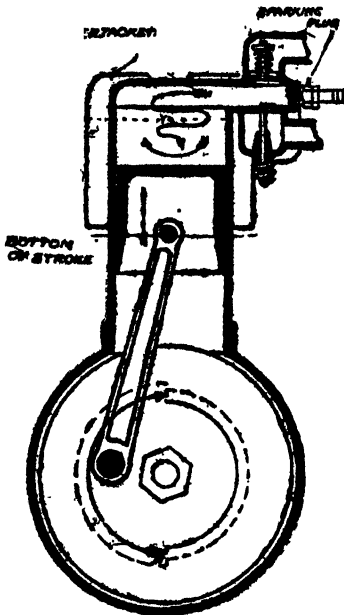


Fig. 2.—COMPRESSION STROKE.

this necessary spark that the ignition apparatus, which I shall describe later, is required.

This type of engine is known as the "internal combustion" engine,

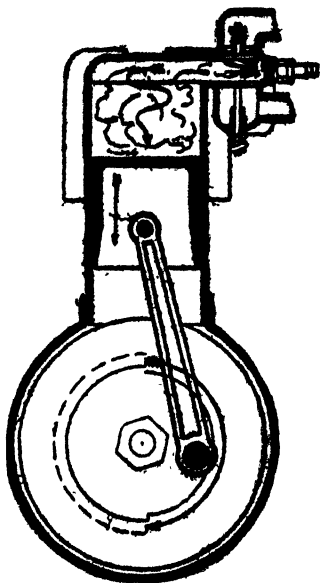


Fig 3.—EXPLOSION OR
WORKING STROKE.

because the whole of its power is produced inside the motor itself, and not by means of any boiler or external generator such as is required to produce the steam for a steam engine. I may say here, for the benefit of those who have some knowledge of the manner in which a gas engine works, that the principle of the gas engine and the principle of the petrol motor are identical in every respect, except that in the former the explosive agent is a mixture of ordinary lighting gas and air

—the gas being brought to the motor by the ordinary gas mains, while in the latter case the necessary petrol vapour for mixing with the air is supplied from a tank carried on the car itself.

The majority of petrol cars at the present day

are driven by a motor working on what is called the Otto cycle principle, in which two complete revolutions of the crank-shaft are required to obtain one effective or working stroke of the motor. By looking at the illustrations this cycle of events will be easily understood. The drawings represent the general details of a motor as it would appear if cut in two down the middle. In order to obtain the first explosion the motor has to be started by hand. This is done by means of the starting handle,

plied with all cars.

The cylinder is fixed and immovable, while the piston, which is a good, but not tight, fit inside the cylinder, is connected with the shaft by the

By the revolution of

the crank-shaft the piston is made to travel up and down inside the cylinder, so that its uppermost surface sweeps the space between the dotted lines,

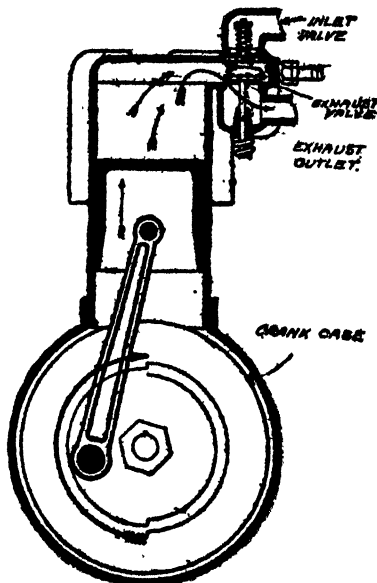


Fig. 4.—EXHAUST STROKE.

Fig. 2. The flywheel, which is attached to the end of the crank-shaft, plays an important part in the working of the motor, as its momentum, when revolving at speed, is needed for raising the piston at every stroke and for that compression of the gases which is required before an explosion can be obtained.

Supposing the piston is at the top of stroke. As soon as the starting handle is turned the piston is drawn downwards to the bottom of the stroke, and, by tending to cause a vacuum in the cylinder, the inlet valve which is only lightly held against its seat by a spring, is opened, thus allowing a great rush of petrol vapour and air to fill the cylinder and combustion chamber.

The momentum of the fly-wheel then comes into action, for by its weight it not only continues to revolve the crank-shaft, but at the same time carries the piston upwards, while simultaneously, as soon as this motion of the piston begins, the induction valve is closed by its spring, thus shutting off any means of egress for the gas inside the cylinder, so that as the piston ascends, this gas, or mixture as it is called, is very considerably compressed in the space between the head of the piston and the top of the cylinder. This space is known as the combustion chamber.

As soon as full compression has taken place it only needs the electric spark to occur at the "points" of the sparking plug to cause the explosion. If we take it for granted that this explosion does now occur at the right moment the effect will be that the gases will expand very considerably and suddenly, and, as no other part of the motor can move, the piston is driven downward with great

force, the action being exactly that exerted by the leg of a bicycle rider, and the energy thus imparted to the flywheel is used by it to continue the rotary movement of the crank-shaft; or, to take another illustration, the effect of the explosion on the piston is just the same as when one turns on the steam into a steam engine.

Having considered the third or explosion stroke of the Otto cycle, the next problem is how to get rid from the cylinder of the waste products of these gases after the latter have done all the useful work of which they are capable. In order to do this, as the piston begins to rise again from the lowermost point, another valve, called the exhaust valve, is raised by the action of a cam, this

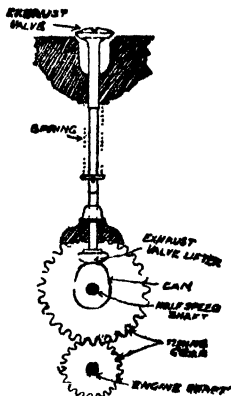


Fig. 5.—EXHAUST VALVE AND CAM.

cam, being on a shaft which has a toothed gear-wheel on the end of it, engaging with a similar, but smaller, wheel fixed on the crank-shaft; the number of teeth on these two wheels being so proportioned that the revolution of the cam-shaft shall be only half as fast as that of the crank-shaft, so that it will be easily seen that the cam raises the exhaust valve only *once* for every *two revolutions* of the crank-shaft; and all the time during which the piston is ascending on this occasion the exhaust valve remains open, allowing the waste gases to escape through

the exhaust pipe, the valve closing immediately after the piston has reached the top. The cylinders now being clear are ready for a fresh charge to be drawn in at the next down stroke, and so these four operations of suction, compression, explosion, and exhaust, continue to occur so long as the motor is kept supplied with the mixture.

The spring-loaded, atmospheric, induction valve has been almost entirely superseded during the last year or so by the mechanically operated inlet valve, which is merely a duplicate of the exhaust valve, and is worked by a cam in precisely the same manner. One great drawback to the atmospheric valve being that, at slow engine speeds, it did not open soon enough or remain open long enough to admit a full charge to the cylinder.

NO. II.—THE COMPONENT PARTS OF THE MOTOR.

HAVING described the principle of the four-cycle motor in the last article, I will now say a few words about the component parts of which the motor is made up, using for the purposes of illustration the end view of a four-cylinder Daimler motor. The upper part of this is made up of the cylinders, with their water jackets and valve chambers, and containing the piston, the valves, and the sparking plugs; and the lower half is known as the crank chamber or base chamber, and carries the crank-shaft, connecting rods, and flywheel.

The cylinders are usually made of cast-iron, in one piece, and are open at one end and closed at the other. It is inside the closed end that the explosion of the "mixture" takes place, and consequently where the power of the motor is generated.

In the top or head of the cylinder are two small openings, into which the induction and exhaust valves fit. Sometimes these openings are situated side by side; or, the induction valve may be on one side of the head and the exhaust valve on the opposite side entirely; but these differences are merely individual ones adopted by this or that maker—the actual functions of the valves are the same in every motor.

The position of the sparking plugs varies also in different types of motors. It may be necessary to state here that a "sparking plug" derives its name

from the fact that it is a device for producing the electric spark inside the combustion chamber of a motor whereby the "mixture" is fired at each compression stroke. It usually consists of a tube made of porcelain or mica (either of which are non-conductors of electricity) contained in a metal plug, which can be screwed into the cylinder head. A wire, connected with the battery and coil supplying

electrical current, passes through the centre of the porcelain, and another piece of wire is attached to the metal plug; the ends of the two wires are about one-sixteenth of an inch apart, and as a result the powerful current of electricity which flows down the central wire has to jump across this gap in order to continue its course, at the same time

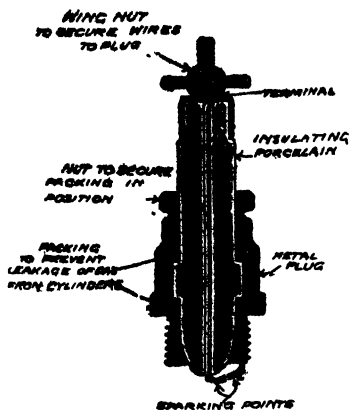


Fig. 1.—SECTION OF PLUG.

causing the brilliant and hot spark which explodes the charge. Sometimes the sparking plug may be found either between or on one side of the valves, or right in the centre of the cylinder head. Scarcely any two makers are agreed as to which is really the best position.

The upper or closed end of the inside of the cylinder is termed, as I have already said, the

"combustion chamber," while the small portion of this space which remains when the piston is at the top is called the "compression space"; and when a novice hears a motor described as having a "very high compression," he may safely assume that the space between the top of the piston and the head of the cylinder is quite small, consequently the mixture during the compression stroke (see Fig. 2) is under very considerable pressure, often as much as 80 lb. to the square inch.

Each cylinder is provided with two valves, the induction valve and the exhaust valve. The function of the former is to admit the "mixture" into the combustion chamber, while that of the latter is to open at the right moment—*i.e.*, at the completion of the explosion stroke—and to remain open long enough for the escape of the products of combustion after each working stroke of the motor. The piston is made of cast iron, and is a good sliding fit in the cylinder. It cannot, of course, be made a sufficiently tight fit in itself to prevent the loss of compression, as in this case there would be room neither for lubrication nor for the expansion of the metals when the motor was working, and consequently hot. Therefore, to provide for this, every piston has three or more square grooves cut round the outside of its circumference near the top, and into these grooves are sprung cast-iron rings, which have sufficient elasticity in them to press outwards against the walls of the cylinder, and in this manner to secure a gas-tight joint. Great care has to be exercised to keep these rings properly lubricated, as their efficient working depends almost entirely upon the attention they receive in this respect.

The connecting rod is the medium through

which the direct up-and-down motion of the piston is transformed into the rotary movement of the crank-shaft. The base chamber forms the support for the cylinders, to which it is bolted, and also for

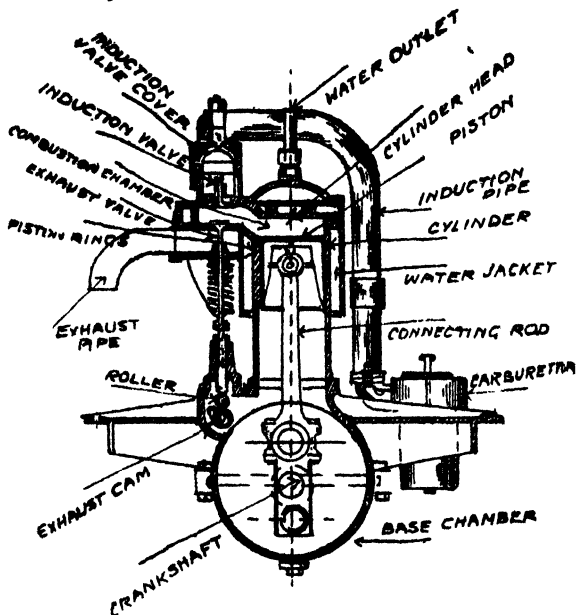


Fig. 2.—COMPONENT PARTS OF MOTOR.

the bearings of the crank-shaft, while the arms which project outwards on either side are intended for fixing the motor to the frame of the car and thus securing the necessary rigidity for transmitting the power of the motor to the change-speed gear.

This base or crank chamber also performs a very useful work in containing lubricating oil, into which the cranks dip at each revolution, and in this way the oil is splashed about, and the crank-shaft bearings kept sufficiently lubricated. When starting a motor for the first time about a pint of oil has to be put into the crank chamber for this purpose, and care must be exercised in renewing this from time to time so as to keep the same amount there always, as, should the level of the oil be allowed to get too low so that the cranks fail to touch, serious damage to the motor will be the immediate result.

No. III.—THE SPRAY CARBURETTER.

THE action of the spray carburetter is entirely different to that of the surface carburetter; for, whereas in the latter the mixture consists of petrol vapour and air, in the spray type a certain quantity of air and petrol in the form of spray is drawn into the cylinders together, a thorough mixing of the air and petrol spray taking place during its passage from the carburetter proper to the cylinders of the motor.

A clearer appreciation of this will be obtained by a study of the accompanying illustration, which shows the spray type carburetter in quite its simplest form, adapted to a two-cylinder motor.

As soon as the petrol enters the float chamber through the supply pipe it causes the float to rise. Now, the top of the float has two rocking arms, pivoted to lugs cast on the cover of the float chamber, resting upon it. As the float rises the outer ends of the rocking arms rise with it, and their inner ends, which rest in a grooved collar attached to the float spindle, gradually depress this spindle until, when the petrol inside has reached a certain level, the pointed lower end of it closes up the orifice through which the petrol is rushing; it will be clear, therefore, that until the float is depressed again no more petrol can pass.

The float chamber communicates with the jet through the narrow passage which is seen in the illustration, and the float is set so that it cuts off the petrol supply as soon as it rises to within

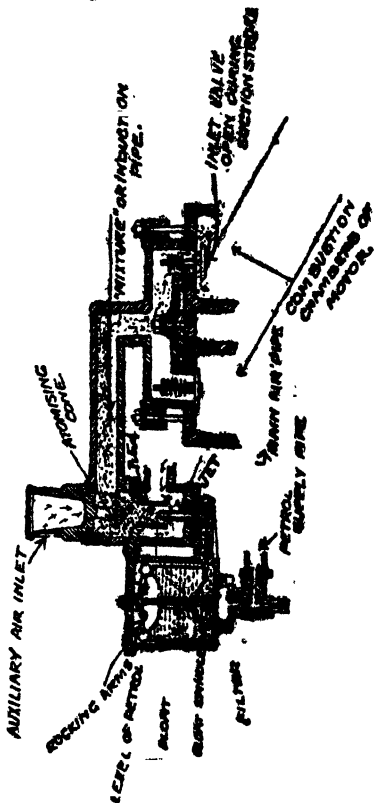
about $\frac{1}{4}$ th of an inch from the top of the jet. As soon as the first suction stroke of the motor takes place air rushes in through the main air pipe to fill up the vacuum caused in the induction pipe. In so doing it is obliged to travel at great speed through the narrow annular passage around the jet—this is clearly shown by the direction of the arrows—and in doing so it draws with it petrol from the jet, and the two impinge upon the atomising cone in such a manner as to become thoroughly mixed in the form of a fine spray, and in this manner it passes to the cylinders.

The quantity of petrol used at each stroke of the motor naturally lowers the level of petrol in the float chamber, and by allowing the float to sink the float spindle rises and admits more petrol, so that the level is automatically kept constant. An auxiliary air inlet is provided, so that in very hot or very cold weather the proportion of air to petrol may be varied more or less.

The spray carburetter is undoubtedly simple, and if ordinary care is used in seeing that no water or grit finds its way into the petrol tank there is but little chance of the jet becoming blocked. There should be at least one filter of fine wire gauze interposed somewhere in the passage from the petrol tank to the float chamber, as if this is done, and the filters are cleaned from time to time, then, even if by accident some foreign matter were to find its way into the tank, it could not do any harm. In the carburetter illustrated this filter will be noticed just underneath the float spindle.

Upon the accurate adjustment of the carburetter in the first place depends to a great extent the power which will be developed by the motor.

The orifice of the jet is exceedingly small, and both this and the air apertures have to be most delicately adjusted to get the best results. Most carbureters are adjusted for a certain engine speed, and, as a consequence, so soon as this speed is reduced the power of the motor is impaired; this is because the suction is less vigorous at the lower speed, and consequently less petrol is drawn from the jet, thus affecting the proportions of air to petrol. To overcome this defect some types of carburetter, such as the Krebs, Napier, and others, are so fitted that, as soon as the engine speed drops, the auxiliary



air inlet is automatically reduced in size or even completely closed, so that the suction of the motor has then a greater effect in drawing petrol from the jet, and the quality of the "mixture" remains constant. Needless to say, such an automatic method of dealing with the subject requires to be very nicely calculated and carried out.

In some types of carburetter this variation can be made by hand, perhaps the best example of the latter type being the Longuemare; but, as it necessitates a good deal of attention on the part of the driver if the best results are to be obtained, the automatic method is decidedly preferable. In order to assist the vaporisation of the petrol as it emerges from the jet it is often necessary to apply a certain amount of warmth; this is particularly the case in the winter, and for this purpose the mouth of the main air-supply pipe is carried to within about half an inch of the exhaust pipes, the heat from them being sufficient to make an appreciable difference to the temperature of the air entering the pipe. Or, in some cases, a chamber having two outlets is formed round that part of the carburetter surrounding the jet, and either part of the hot exhaust gases from the motor, or water from the water-circulating system, is caused to pass in at one end of this chamber and out at the other, in this way producing the same effect.

There are two methods of insuring a constant flow of petrol to the float chamber—namely, by having the supply tank fixed on the car in such a position that it shall always be at a higher level than the float chamber, wherefore the petrol will be fed automatically by gravity, or by introducing pressure into the tank. In the latter method the

pressure is first obtained by some sort of hand-pump, and then, when the motor is once started, it is maintained by introducing a small portion of the exhaust gases through a suitable valve which opens to the tank as soon as the pressure falls below a certain point. There are arguments for and against both these arrangements: With gravity feed, the tank, which in large cars has often to hold as much as twenty gallons, must be located against the dashboard or underneath the front seat, thus either looking very unsightly or else taking up valuable space which could be usefully occupied for carrying tools or luggage. Furthermore, when the petrol has run low in the tank it may often seriously affect the "pull" of the motor up very steep hills, if indeed it does not cease to supply the carburetter altogether. I have known many cars, of otherwise good design, which have had no end of trouble on steep hills because their petrol supply was either insufficient in quantity or failed altogether just at the critical time when the motor was exerting its greatest power, and therefore making the heaviest calls upon its fuel. However, many people prefer gravity feed as being safer than pressure feed, arguing that if a pipe breaks, the spirit will only fall directly on to the ground, whereas if the same mishap occurred under the pressure system the spirit might be spurted about in all directions, and, if at night when the lamps are alight, with disastrous consequences.

The pressure-fed tank can be neatly stowed away below the body of the car, where there is more room for a larger tank and a bigger supply of petrol, thus obviating the necessity, which so often arises when touring on a gravity-fed car, of carrying

spare tins of petrol stowed away amongst, and to the discomfort of, one's passengers; and furthermore, the pressure will make it certain that the engine is supplied with fuel at the same rate until the very last drop is used up. I think the only solid objection to the pressure-fed petrol supply is the liability of leakages in the joints of the pressure pipes or in the controlling valve, and when these occur they are certainly sometimes difficult to locate.

NO. IV.—THE GOVERNOR—VARIOUS SYSTEMS.

OWING to the sudden variations of the "load" put upon a motor—*i.e.*, in the amount of work it is called upon to perform—it is extremely necessary that it should be provided with some means of automatically controlling the number of revolutions it is capable of making. Everyone will realise that when once the motor is started, if it has no work to do which will absorb its power, it will very shortly attain such a terrific speed as would not only set up very great vibration, but might be reasonably expected to result in damage to the working parts of the motor itself; similarly, let it be supposed that the motor is exerting its full power in propelling the car along the road, when, all at once it may be perhaps necessary for the driver to withdraw the clutch which transmits the power from the motor to the road wheels, thus suddenly relieving the motor from its "load"; the result will be that all the horse-power, let us say ten, for the sake of example, which a moment before was being used in driving the car, will now be occupied in the unprofitable task of increasing the number of revolutions per minute of the flywheel. It is therefore the function of the governor to prevent this undesirable acceleration of motor speed, and I hope in this article to describe, in as simple a manner as possible, some of the various arbitrary methods in use for preventing a motor from increasing its speed beyond a certain fixed maximum number of revolutions per minute.

By Varying the Time of Ignition.

The principle of this form of governing is, that if the electric spark, which ordinarily, at each explosion stroke of the motor, fires the charge in the cylinder when the piston is near its *highest* point in the cylinder, is not allowed to occur until the piston has travelled some distance on its *downward* stroke, it follows that the expansion of the gases, which takes place when the mixture is fired, will not exert so much force as they would do in the ordinary way, because they are, of course, not so highly compressed; and, furthermore, the exhaust valve opens and permits them to escape before their energy is expended. The result is that by retarding the spark in this manner the power of the motor may be reduced to any required extent, and its speed controlled. The system, although extremely simple, has two very serious drawbacks. First, it is very wasteful, because, as I have stated above, with retarded ignition only a small portion of the energy developed by each explosion is made use of. Secondly, and this is a still more important point, retarding the ignition leads to the overheating of the motor and damage to the exhaust valves.

To make this more clear it will be necessary for me to explain that the temperature of the flame produced when the explosion takes place in a petrol motor is from 1,800 to 2,000 degrees Cent.; now, if the charge is fired at the proper time, a large proportion of this heat will have been absorbed during the downward stroke of the piston, before the exhaust valve opens; part of this loss of heat being due to the cooling influence of the cylinder walls—which, it will be remembered, are surrounded

for this purpose by a water jacket—and part due to the expansion of the gases whilst doing work. Now if the sparking is retarded so that the explosion does not take place until the piston is nearly halfway down the cylinder, there will have been no time for the temperature to have dropped more than a few hundred degrees before the exhaust valve opens, with the result that a volume of intensely hot flame, instead of a comparatively cool flame as it ought to be, rushes out through the exhaust port and heats not only the exhaust valve, but all the metal round it, including the exhaust pipe, to a red heat. The effect of this can often be seen on motors governed in this manner by the way in which the exhaust valve and its stem is burned away, causing endless trouble to its owner owing to the frequent necessity for grinding in or renewing the valves. It is obvious, therefore, that the method of regulating the speed of the motor by retarding the point of ignition is one to be condemned.

Governing by Throttling the Exhaust.

This arrangement has not found much favour, although it has certainly been used with some success on De Dion motors. By means of it the driver is able to control the amount of opening given to the exhaust valve. When the motor is working at full power the exhaust valve is permitted to open to its full extent, but when less power is required the position of the valve lifter, in relation to its cam, is altered in such a way as to prevent the exhaust valve from opening fully, so that all the exhaust gases cannot escape before the valve closes, with the result that on the next

suction stroke there is no room for a full charge of fresh gas, and a weaker explosion takes place.

Hit-and-Miss Governor.

This is an economical method controlling the speed of the motor, and until recently was almost universally adopted for petrol motor work. In this system, as soon as the motor exceeds the maximum speed at which it was designed to run, a mechanical contrivance automatically prevents the exhaust valve from rising at all, with the result that the cylinders remain full of exhaust gases, and consequently no fresh charge can be drawn in until the speed of the motor has fallen below the maximum again, when the exhaust valve is then allowed to open, and the ordinary cycle of revolutions goes on as before. The mechanism which effects this system of governing is extremely simple. It consists of two weights attached to the gear wheels driving the shaft on which the exhaust cams are fixed. These weights are of such a shape and pivoted in such a manner, that as the speed of the engine increases the weighted ends have a tendency to fly outwards, this movement operating a system of levers in such a manner as to push the jointed exhaust valve spindle to one side, just far enough to be missed by the valve lifter as it rises for the purpose of opening the exhaust valve. One objection to this system is that the working parts required for it are numerous and liable to a considerable amount of wear and tear, with a result that they become noisy, and often need repair or renewing.

Variable Lift Induction Valves.

This consists in regulating, either automatically

or by hand, the amount of opening given to the induction valves. Thus, if the valves are only opened to a small portion of their full extent they will not admit a full charge of gas into the cylinders, with the result that a weaker explosion will take place. This method tends to quiet running, as it enables the power of the motor to be altered very considerably, and in proportion to the work it is required to do, but at the same time, in order that this variable lift may be properly effective a considerable number of moving parts are necessary, whilst, furthermore, it is not economical, as owing to the reduced charge, the compression in the cylinders is lessened, and consequently the petrol consumption per horse-power is greater than if the proper volume has been maintained.

Governing by Throttling the Mixture.

The throttle governor consists of some form of valve fitted between the carburetter and the induction valves of the motor. It is usually operated by a weighted governor of a similar type to that used in conjunction with the hit-and-miss principle of governing, and when the sleeve on the cam-shaft is pushed forward by the governor arms it operates the throttle valve by means of a system of rods and levers, so that directly the engine speed increases beyond the normal, the throttle valve automatically reduces the size of the passage through which the mixture passes, and in this way reduces the power of the motor by preventing the full charge being drawn through the valve. This system, although very handy, has also the disadvantage of not giving the best results for a given volume of mixture.

No. V.—HIGH TENSION IGNITION.

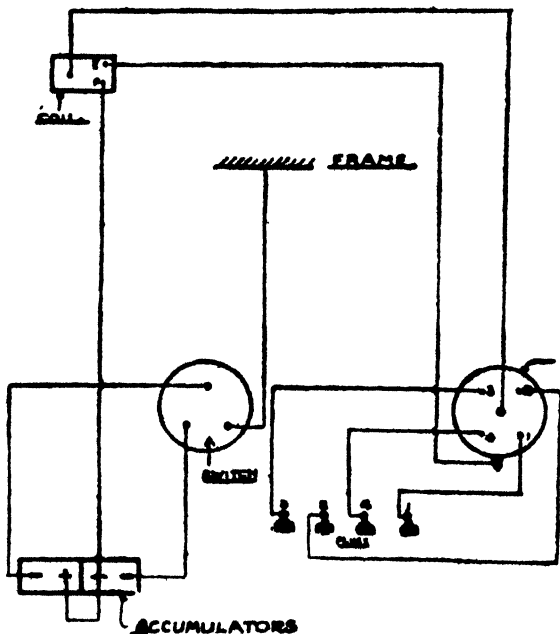
THE generally accepted method of igniting the charge in the cylinders is by means of an electric spark which is caused to take place when the "mixture" has been compressed by the upward motion of the piston. The electricity may be supplied either through a storage accumulator or by means of dry batteries, or it may be generated by a magneto machine. With the former system the current given by the accumulator is transformed from low to high tension by means of an induction coil, but with the latter method either high or low tension current may be used.

With accumulators there must be some means of re-charging when they run down in power, but the magneto machine is a mechanical contrivance for producing electricity, and will continue to supply current so long as the motor is running; so that beyond the fact that it absorbs a certain amount of power to drive, the cost of electricity produced in this way is practically nothing.

The various parts which go to make up an installation of high tension ignition with accumulators are:—(1) The accumulator; (2) The induction coil; (3) The commutator; (4) Sparking plugs; (5) Switch; (6) Insulated conducting wires.

The accumulator is usually "charged" from some source such as the wires which distribute current for the town supply. Generally two accumulators are used coupled together in series and giving off rather over four volts pressure. This

pressure alone would be useless as a spark-producer inside the cylinder, so the help of an induction coil is called in, which is capable of transforming the

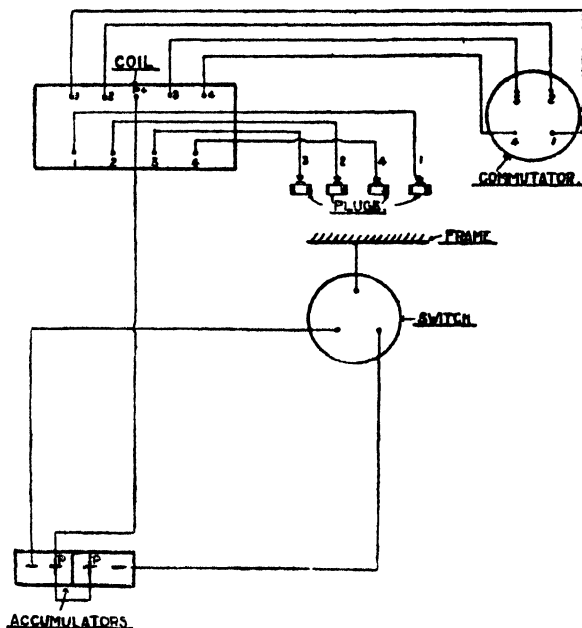


METHOD OF WIRING WITH SINGLE COIL
DISTRIBUTER.

four volts current into one at a pressure of several hundred volts.

The elementary facts which explain how a low

tension current of four volts can be transformed into a high tension current are as follows:—
Supposing one takes a bundle of iron wires and



METHOD OF WIRING WITH QUADRUPLE COIL
AND COMMUTATOR.

wraps round them a few layers of ordinary thick insulated copper wire, and then passes a current of electricity through the latter, the effect is to

convert the bundle of wires into a magnet, and if, going farther, a number of turns of very fine, insulated, copper wire be wound over the first layer of thick wire, then an "induced" current may be set up in the secondary wire. The difference in the intensity of the "induced" current and that of the primary current varying according to the number of layers of fine wire which are used. This is the principle utilised when constructing the induction coil which transforms the low tension current of the accumulator into the high tension current necessary to produce a spark of sufficient intensity to bridge the air-gap between the points of the sparking plug within the cylinders.

The commutator is required in order to break the current in the primary circuit just before the completion of the compression stroke of the engine, because the act of breaking the primary circuit causes a high voltage induced current to flow round the secondary circuit, and in its passage to bridge the distance between the points of the sparking plug in the form of an intensely hot flame. The commutator is usually a fibre insulating disc attached to a shaft which revolves at half the speed of the crank-shaft, there is a short metallic segment in this disc which is in direct contact with the above shaft, the disc is revolved against a roller or brush in such a manner that when the roller or brush is in contact with the metal segment the primary circuit is closed and a magnetically operated trembler attached to the coil causes, by its vibrating action, a stream of sparks to occur at the points of sparking plug.

The construction of the sparking plug is described on page 10.

The switch is a small fitting usually placed on the dashboard by means of which the driver can interrupt the current flowing from the accumulators to the coil. Upon the suitability of the conducting wires and their proper insulation may depend to a great extent the immunity from breakdown enjoyed on a car. The greatest attention should be given to this matter, for bad insulation, especially when occurring in the high tension wires leading from coil to sparking plug, will spell endless trouble by causing short circuiting, *i.e.*, allowing the current to pass back through the frame of the car instead of across the space at the sparking plug points.

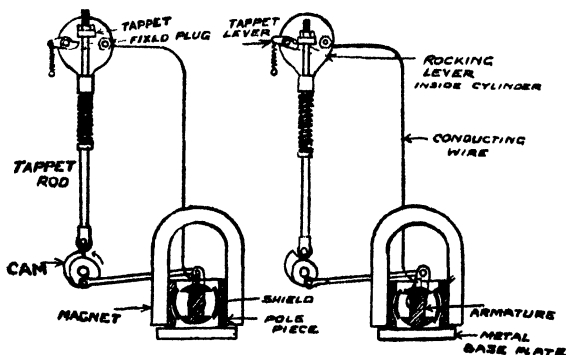
Trouble with this system of ignition may be due to faulty sparking plugs, these being either sooty or broken; loose connection at some one of the many wire terminals; broken wires; worn or otherwise damaged commutator; accumulators which are "run down" and want recharging, and finally it may be that the tremblers on the coil are out of adjustment, either working sluggishly or not at all.

No. VI.—MAGNETO IGNITION.

THERE are two systems of magneto ignition in use, one of these being termed low tension and the other high tension. The application of either, but especially the low tension method, is comparatively simple; the theory, however, requires careful study embracing a very large field, and is outside the scope of the average beginner. (I recommend those of my readers who desire to gather a full knowledge of all branches of electric ignition to obtain "Motor Ignition Appliances" from the Cycle Trade Publishing Company, Ltd.)

In the Simms-Bosch system, which is the best known, three horseshoe magnets with curved pole pieces are used, and in between the concave faces of the pole pieces is a fixed armature, composed of I-section iron, round the channels of which are wound a large number of turns of insulated copper wire. A soft iron shield is interposed in the space between the armature and the pole faces, and this is oscillated by mechanical means so that it alternately exposes the armature to and screens it from the "lines of force" passing across the magnetic field—the latter term signifying the space between the "N." and "S." poles of the magnets—by this means setting up a current of variable intensity in the armature, from whence it is conveyed by a single wire to a make and break

mechanism on the motor. The apparatus for causing the spark in the cylinder is as follows:— A cam on the half-speed shaft is made to lift at every alternate revolution of the engine a vertical rod carried in guides at the side of the cylinder, and having a tappet arm fixed to its upper end. On the side of the cylinder head is fixed a plate, into



Just before firing.

Point of firing.

SIMMS-BOSCH MAGNETO.

which is screwed an insulated metal plug projecting into the combustion chamber—this plug is connected to the terminal of the armature by a single wire—and a spindle which passes through the plate, carrying on its outer end a rocking lever and on its inner end a short arm which is normally held in contact with the end of the insulated plug by a spring.

At one position just about the end of the compression stroke of the motor, the cam allows the tappet arm to fall so that it strikes the rocking lever, which in turn suddenly breaks the contact between the short arm and the metal plug inside the cylinder just at the moment when the current set up in the armature is at its maximum intensity. The result of the sudden interruption of the circuit being that a hot, flaming spark is produced between the fixed plug and the short arm as it moves out of contact.

The system is extremely simple, and there is no complicated wiring to attend to or great liability to short-circuiting. On the other hand, there are the objections that the contact pieces inside the cylinder gradually burn away, and this means that it is somewhat difficult to keep them adjusted on a multi-cylinder engine with such nicety that the synchronisation of firing shall not be affected; also there is the chance of compression leakage past the spindle carrying the rocking arm, together with the necessity for a special form of motor construction, and a few minor disadvantages such as the noise inseparable from the action of the tappets.

The high tension magneto system is now a very popular one. The machine for producing the current is also built up of horseshoe magnets, and usually has a revolving armature, but the difference between it and the low tension system lies in the fact that the low tension current is transformed into a high tension current by utilising the services of a separate induction coil and condenser—as with the accumulator system—and then distributing the current to ordinary sparking plugs in the cylinders. This is done in the Eisemann system. By adding

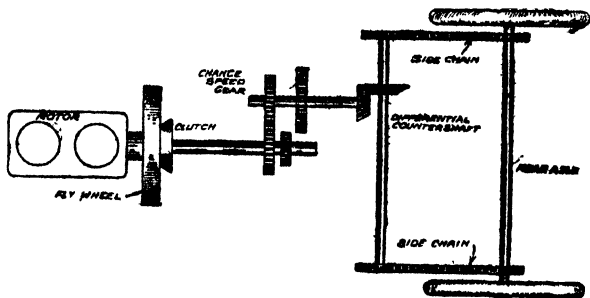
a secondary and highly insulated winding of fine wire to the armature, it is equally possible to induce a high voltage current of electricity which, with the help of a separate condenser, may be utilised for sparking purposes, a method employed by both Bassée Michel and Simms-Bosch.

No. VII.—TRANSMISSION GEAR.

IN order to clearly understand the function of transmission gear in a petrol-driven car, the novice must first of all bear in mind the fact that the power of a petrol motor is not elastic, like steam power, and, furthermore, that a motor will only develop its full power so long as it is kept running at the maximum number of revolutions per minute which its makers designed for it. So, as an example, we will suppose that a 10 h.p. motor is just sufficiently powerful to propel a car at twenty-five miles an hour on a level road, then it will at once be obvious that as soon as a hill is encountered, the motor will naturally begin to slow up, and since we know that loss of speed means loss of power where the petrol engine is concerned, so in order that the motor shall still be able to maintain its normal number of revolutions and therefore continue to give its full power, it is necessary to interpose between the motor and the road-wheels some form of reducing gear—usually this takes the form of cog-wheel gearing—which, while allowing the speed of the motor to remain constant, shall have the effect of reducing the speed of the road-wheels from, let us say, twenty-five miles to fifteen or even seven miles an hour, according to the steepness of the hill, and in this way the difficulty of having no reserve of power to draw upon is overcome.

It will not be necessary for me to describe all the various types of gear which are in use on different cars, and I shall therefore take, as an

example, that which is commonly termed the Panhard gearing, as this is the simplest form in use. With this type of gearing the motor is usually a vertical one with the crank-shaft lying parallel to the length of the car. The transmission gear consists of a clutch, the change-speed gear, the differential gear, and the chains which transmit the power from the gear-box to the driving wheels. The clutch is necessary for two reasons; first, because the internal combustion



PRINCIPLE OF DRIVE BY SIDE CHAINS.

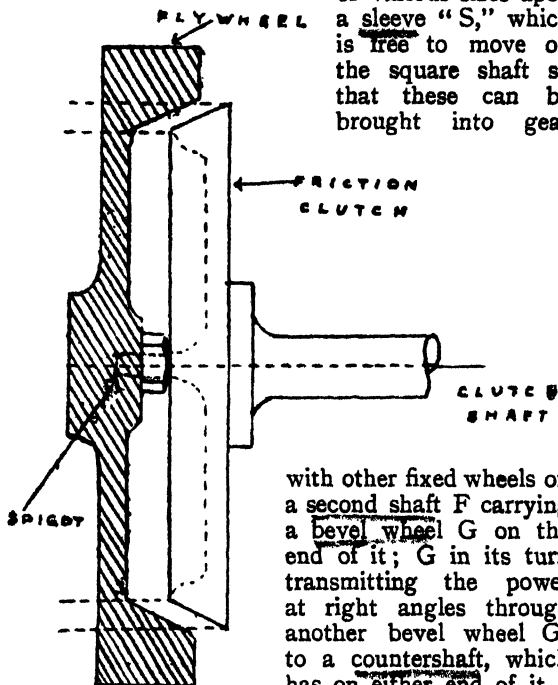
engine has to be started by hand before it is ready to transmit its power to the road wheels, and this could not be done if the engine was rigidly connected with the gear, as is the case in a steam car; and secondly, that whenever by the exigencies of traffic it is necessary to stop the progress of the car very suddenly there must be some means of cutting off the power; with a steam engine it is only necessary to shut off steam and stop the engine,

but if a petrol motor is stopped it would have to be restarted by hand; the clutch therefore fulfils these two requirements by forming a method of connection between the motor and gear, which can be instantaneously broken by the driver. The means used for operating the clutch is generally a foot pedal. Most clutches are of the friction type as shown in the illustration, which very clearly indicates the usual form it takes.

Special attention should be paid to the flywheel of the motor, in which it will be noticed there is a conical-shaped recess; the friction clutch; the shell, which is usually made of aluminium, the outside edge being covered with leather; the spigot which fits into a recess in the end of the crank-shaft and serves to keep the friction clutch in a central position when it is withdrawn from actual contact with the flywheel. The friction clutch is securely fastened to the clutch shaft which carries the change-speed gear.

It will readily be seen that when the friction clutch is brought into close contact with the recess in the revolving flywheel, a grip will be obtained which, to all intents and purposes, forms a rigid connection between the gear-shaft and the motor. Beyond acting as a means of transmitting the actual power from the motor to the gear, the clutch has also the very useful property of enabling the car to be started without undue shock to the gear, as until the clutch is thoroughly engaged with the flywheel it has a certain amount of slip which has the effect of applying the power gradually through the gear to the road wheels. The shaft on which the clutch is carried and which is usually known as the clutch-shaft, is supported by the gear-box on two

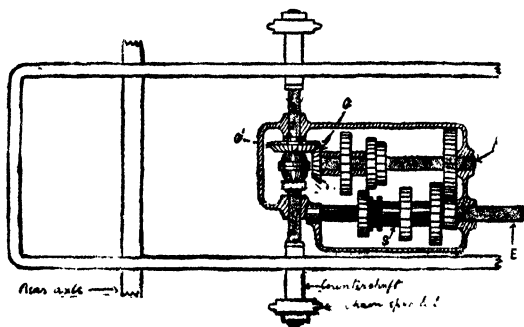
bearings, one at either end of it; this clutch-shaft is usually square in shape, *i.e.*, the portion within the gear-box, and carries three or four cogwheels of various sizes upon a sleeve "S," which is free to move on the square shaft so that these can be brought into gear



with other fixed wheels on a second shaft F carrying a bevel wheel G on the end of it; G in its turn transmitting the power at right angles through another bevel wheel G^1 to a countershaft, which has on either end of it a chain sprocket pinion, and

finally these pinions apply the power through chains to other sprocket wheels rigidly attached to the rear road wheels of the car.

The cogwheels on the shaft E and those on the shaft F are of unequal sizes, and in order to change from one speed to another the sleeve S is moved along the square shaft E by means of a fork which is interconnected with a lever fixed conveniently to the hand of the driver. When on top, or highest speed, the revolutions of the motor are somewhere about four times as fast as those of the road wheels, and this means that the largest cogwheel on the sliding sleeve is in mesh with the smallest wheel



on the second shaft, so it will easily be understood that in order to surmount a stiff hill it is only necessary to slide the sleeve along its shaft so as to bring its smallest wheel into mesh with the largest wheel on the second shaft in order to materially reduce the speed of the road wheels, and therefore the 10 h.p. originally available for driving the car at twenty-five miles an hour is still sufficient to take it up a stiff hill at six miles an hour.

The reverse motion is generally obtained with

a small and wide cogwheel which is brought into gear simultaneously with the low-speed wheels on the two shafts, therefore reversing the direction of motion of the second shaft and consequently that of the road wheels.

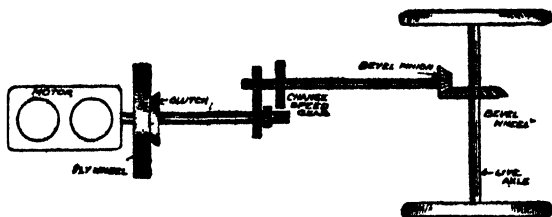
Not only the bearings of the shafts carrying the gear, but the gear wheels themselves need to be kept carefully lubricated, both to prevent undue wear and tear, and also to deaden noise; for this reason the gear-box is usually made oil-tight and is kept about one-third full of heavy black lubricating oil, or a mixture of oil and grease, so that this is thrown about by the revolving wheels and keeps them properly lubricated. The bearings for the shafts are generally supplied from a separate lubricator fitted in front of the driver and under his direct control.

The differential gear (also known as compensating gear) is usually mounted on the countershaft in chain-driven motor-cars, and is required so that when rounding corners the road wheel which is taking the outside of the curve, and has therefore farther to go than the wheel on the inside of the curve, may also be able to travel faster than the inside wheel. It will need but little thought to convince anyone that if there was no provision of this sort for allowing the driving wheels to revolve at different speeds when taking sharp corners, there would not only be great difficulty and even danger when driving at any high speed, but there would be, of necessity, considerable "skidding" of the wheel taking the longest path on the outside of the curve if it was not allowed to make more revolutions in a given time than does the inside wheel which has a shorter distance to travel.

With a horse-drawn vehicle there is no trouble of this sort, because both wheels are free to revolve independently on their axles; but in a motor-propelled carriage the conditions are entirely different, and all the power necessary for driving the car has to be transmitted through the two rear wheels.

The most convenient place for carrying the differential gear is the countershaft, because this commands the speed of the road wheels by means of the chains which connect them on either side.

This countershaft is therefore divided in the centre and to each inner end is keyed a bevel wheel, these face one another and are connected by two other bevel pinions also facing each other, these bevel pinions have a short length of shaft attached



PRINCIPLE OF LIVE AXLE DRIVE.

to each, and over all comes the differential gear-box which is made in halves so as to slip on over each end of the countershaft and envelop all the wheels of the differential gear; it also forms bearings for the short lengths of shaft on each bevel pinion above referred to, and when the two halves of this box are bolted together the whole is driven as a solid shaft so long as the car is travelling in a straight line, but as soon as a curve is being

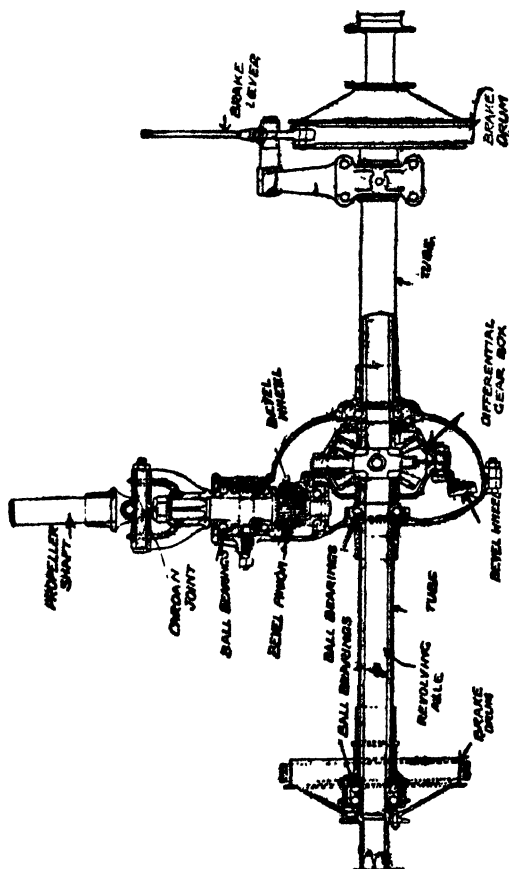


FIG. 1.

described the pinions of the differential gear begin to revolve on their bearings, thus retarding one end of the divided countershaft and allowing the other end to go forward; the motion is very slight, but it is sufficient to preserve the proper relation between the speeds of the two road wheels according to the distance through which each one has to travel.

Another method, which obviates the use of a countershaft and chains, is to transmit the power from the gear-box straight to the back axle by means of a steel shaft called a propeller shaft; the rear axle in this case is not fixed as when a side-chain drive is used, but is a revolving one, hence it is known as a "live" axle.

The change-speed gear is contained in the same type of gear-box as in the other system, but the clutch shaft is extended right through the gear-box to the outside of it, and is there connected to the propeller shaft by means of a flexible or universal joint, properly termed "cardan" joint. The rear end of the propeller shaft, which is also provided with a cardan joint, is carried on bearings in the differential gear-case, and has a small bevel pinion keyed on to it by means of which the power is transmitted to a large bevel wheel secured to the differential gear-box, which, in turn, is a fixture with the revolving back axle.

Hollow tubes extend outwards on either side of the differential gear-case, and usually terminate just outside the carriage springs, which are attached to them; in such cases the revolving axle passes through the inside of this tube, and is keyed to the road wheels in a solid manner, therefore the end of this revolving axle has not only to drive, but to carry the weight of the car also.

There is now, however, a tendency to carry the hollow tube right through to the outside of the road wheels, so as to form a bearing for the wheels, and in such cases the revolving axle is secured to the outer nave plate of the wheel, so that it has nothing to do but drive.

No. VIII.—BRAKES.

THE speed at which a car may be driven, under varying circumstances, with safety to its occupants and to the public, depends absolutely upon the power of its brakes, and too great attention cannot be given to this important part of its mechanism.

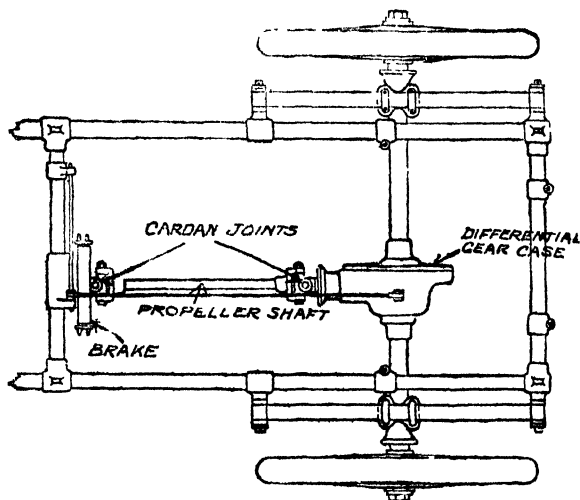


FIG. 2.

Every motor vehicle should have at least two independent brakes; one for general use and the other for an emergency, and both of them should

be capable singly of holding the car equally well either backwards or forwards.

There are two types of brakes in general use, the band brake which operates on the outside of a pulley wheel or drum, and the expanding brake,

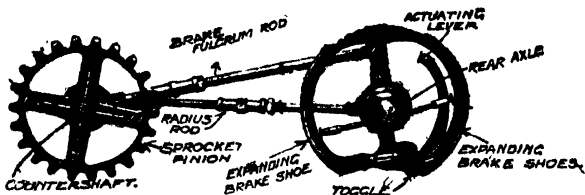


FIG. 3.

which acts, as its name implies, by expansion, on the inside face of a pulley. Brakes applied directly against the tyres are now seldom used, as they are not only very likely to displace rubber tyres, but are extremely destructive to that material. It is usual to operate one of the brakes by means of a foot pedal, and the other by a hand lever.

The foot-controlled brake is generally on the countershaft of those cars which are chain-driven, or where a "live" axle drive is fitted this brake then acts upon a drum on the driving shaft, and may be found either close up to the change-speed gear-box, or else between the cardan joint and the rear axle.

It is becoming increasingly common to find both the countershaft brake and the sprocket brakes working entirely enclosed in a case, so as to protect them as far as possible from mud and dust, and also to deaden the noise made by the rattling of the

brake parts against the brake-drum when the brake is not in operation.

All brakes need very careful adjustment, and it is especially necessary that they should be re-

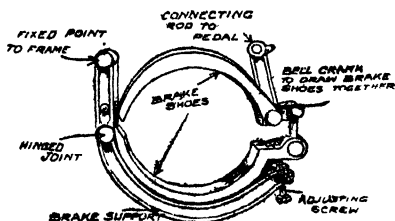


FIG. 4.

adjusted from time to time in order to counteract the effects of wear and tear. Brakes lined with wood, vulcanised fibre, or leather, should not

be tolerated, as they are very liable to burn under a long continued application. The best form of brake is, undoubtedly, that in which metal-to-metal surfaces are used.

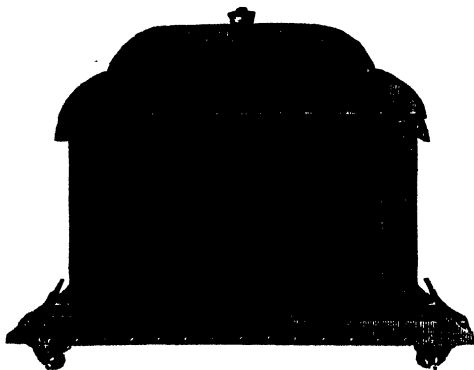
No. IX.—WATER-COOLING SYSTEMS.

ONE of the most important, and frequently most troublesome, portions of the mechanism of a modern motor-car is the water-cooling system, consisting of a water-circulating pump, tank, and radiator.

The necessity for these somewhat cumbrous parts is due to the fact that the temperature of the explosions which take place within the cylinders of the motor, is so high that unless some artificial means of conducting this heat away was adopted, the cylinders and pistons would rapidly become so hot that it would be impossible to lubricate them, as the lubricating oil would be immediately burnt up, with the result that the pistons would stick fast in the cylinders and stop the engine, while besides this trouble the temper would be taken out of the valve springs, the sparking plugs would probably crack, and the "mixture" would become so rarefied as to seriously impair the power of the engine from that cause alone. It is for these reasons that we find every motor, except those of 2 h.p. and 3 h.p. used on bicycles, fitted with a water jacket, so that as the water is constantly circulating through this it takes up a considerable portion of the heat from the cylinder walls, and keeps them at a sufficiently low temperature for working purposes.

In the early days of motoring the water-circulating system consisted merely of a large tank holding perhaps 15 gallons of water, and a pump driven by the motor drew water from the bottom of this tank and forced it through an opening at the

lowest point of the water jacket, and out at the top, whence a pipe conducted the stream back again to the tank. It will be easily realised that in this way the temperature of the water was soon raised to boiling point, and waste of water, in the form of clouds of steam, began to occur; the result being that one had to stop one's car every thirty or forty miles—sometimes more frequently than this—to fill up the tank with cold water.



THE "COVENTRY" RADIATOR.

The objections to this system were so obvious that it was not long before makers began to interpose some form of radiator between the tank and the motor.

The early radiators—and they are still much used—were constructed by threading a number of thin metal rings or discs, soldered into position, upon a length of copper pipe, which was then bent into a continuous zigzag form. This presented a

much larger surface for the cooling effect of the air to act upon as the car was in motion, and it was found that by increasing the size of this radiator and placing it in front of the car, that not only need a less volume of water be carried, thus reducing weight, but that the car could be driven for a whole day upon one supply. Latterly, however, a still more efficient radiator has come into use, this being known as the honeycomb, or "nid d'abeilles" type. It consists of a large number of straight, horizontal tubes, which may be either round or square in section, placed as close as possible together, so as to look, as its name implies, very like a honeycomb; these tubes are contained in, and surrounded by, a tank holding about two gallons of water; the ends of the tubes pass through the sides of the tank, and are held in position and prevented from leaking by being soldered. It will be seen, therefore, that the body of each tube is surrounded throughout its length by a thin covering of water, and cold air is continually passing through the tubes from end to end, so that, in this way, the water is kept at a comparatively low temperature, and evaporation is so slow that a radiator sometimes remains in constant use for several hundred miles, without needing the addition of fresh water. In many cars this cooling effect is still further enhanced by mounting a fan, usually driven off the engine shaft by a belt, immediately behind the radiator, so that, when the car is traveling slowly or standing still with the engine running, air is still drawn through the tubes at a high speed. The pumps used for maintaining the water circulation are usually of the centrifugal type, where a number of fan-shaped arms revolving inside an

enclosed chamber serve to force the water at a high speed through the water jackets of the motor. Such pumps are driven in a variety of ways, the simplest being by means of a friction wheel, carried on the pump spindle, in contact with the flywheel of the motor. This method, however, suffers from the objections that if the friction wheel is too hardly pressed against the flywheel, great wear and tear takes place in the bearings of the pump spindle, and water leakage is sure to take place, or, if the wheel is in too light contact the result will be "slipping" between the two faces and consequent interruption in the circulation. It is now very usual to find the pump spindle fitted either with a toothed gear wheel and driven direct from a similar wheel on the engine, or else driven by means of a chain. Either of these methods is to be preferred to the friction drive, except as regards complication and accessibility.

Some few cars, however, rely upon what is known as the thermo-syphon system of water circulation. In this the water tank is situated higher than the tops of the cylinders and the radiators are placed on either side of the motor, as on the Renault and Chenard and Walcker cars. Cold water enters at the lowest point in the jackets, and becoming at once heated it naturally rises and passes away through the outlet pipe on the top of the jacket, and flows into the tank, from whence it passes by gravity to the radiators, and back again to the engine. It will thus be seen that the thermo-syphon, or natural system of water circulation, depends entirely upon the laws of nature, but it must be admitted that in very hot weather it is not quite as efficient as the methods already described.

An illustration is given of one of the latest types of radiators, known as the "Coventry." In this the radiating fins are really circular discs, stamped out of sheet aluminium, in such a manner that they are left with a serrated flange on the side which comes next to the tubes. The hole in the disc is slightly larger in diameter than the tube, but the serrated flange or sleeve grips the tube tightly. The first disc is threaded on to the tube, and then followed by another which is backed up on to the teeth of the flange, over which it laps for about $\frac{1}{4}$ in., locking it tightly on to the tube. This goes on until the whole length of the tube is covered with these discs, all of them being in close contact with the tube and absolutely self-locked on to it, no solder whatever being required except that necessary for securing the flange to each end of the tube for the purpose of connecting it with the water tank above and below. This type of radiator is stated by its makers to combine all the advantages of lightness and efficiency which are obtained with the use of a honeycomb radiator without the disadvantages of fragility and high cost.

NO. X.—THE MANAGEMENT OF A MOTOR-CAR.

It is somewhat extraordinary, but nevertheless true, that quite a large number of people abstain from motoring for no better reason than that they fear they will never learn to drive and manage their own car. They look upon a motor vehicle as such a complicated piece of machinery, that mechanical training or knowledge is necessary before the average layman can hope to successfully run his own car.

There can be no greater fallacy than this. Learning to drive a motor-car is little or no more difficult than learning to ride a bicycle; while the amount of knowledge necessary to keep a car, of average good make, on the road, is by no means as great as many people imagine. A breakdown on a modern motor-car is of very rare occurrence, provided that the car receives proper and regular care, not only during its journeys but also in its shed. It is only the haphazard driver, the man who looks upon his car as an automatic machine, who suffers to any extent from breakdowns on the road. These are less frequently due to want of mechanical knowledge or aptitude on the part of the owner than to sheer lack of attention.

It should become an article of faith with every novice to look upon his car as a thing of life, and from the first day of possession it should be treated as though it was as capable of feeling ill-usage as a valuable horse, and just as likely to have its life and usefulness impaired by inattention.

When beginning to drive it is almost impossible to be too cautious. "*Festina lente*" should be taken as a maxim, for nothing is gained by an undue anxiety to put on speed. Bad form in driving is very easily acquired during the early stages, and is very difficult to eradicate afterwards.

It should be the desire of every motorist to drive in as clean and finished a manner as possible; he should appear always to be handling his car without effort. Perhaps nothing is more ludicrous than the sight of a heavily clad and goggled motorist crouched low over the steering wheel of a noisy voiturette and doing possibly twenty miles an hour, but giving everyone the impression that his one idea is speed, and that he has no eyes or thought for anything in the world beyond his own desire to get the very last ounce of power and mile of speed out of his car, to the entire disregard of all else on the road.

It may not be generally known, but it is nevertheless a fact, that there are many drivers of notoriously fast and high-powered cars on the road to-day who have been steering motor vehicles ever since the 1896 Act was passed, and have never yet come under the ban of police persecution. Their immunity—as they will admit—is almost entirely due to their manner of driving, and to the fact they never *appear* to be in a hurry, or to be disregarding other people on the road.

Whether your driving "form" is good or the reverse will make all the difference to your reception with police and public alike.

The first lesson should consist of a thorough explanation of the method of filling up petrol, water, and lubricating receptacles; then the best

position for the lever operating the advancing and retarding of the electric ignition should be carefully noted (ignition should always be well retarded before starting the motor), and also the position of the lever operating the throttle valve. The speed lever should be in the "neutral" notch, so that the car may be what is termed "out of gear," and the hand brake lever should be applied in such a way as to prevent the car from moving from any inadvertent cause.

These precautions having been taken, the motor itself should be started and stopped several times until this operation can be done without considerable effort. It is always better to place the starting handle in such a position that it has to be pulled upwards rather than to place the handle at the top of the stroke and then push it downwards, because, in the event of a backfire—or premature explosion—one may very easily suffer a sprained wrist if the latter position is adopted.

The driver having taken his place on the driving seat, the clutch pedal is depressed, the hand brake removed, the speed lever pushed forward into the first speed notch, and the ignition lever slightly advanced; the clutch pedal is then allowed to rise gently, and the car immediately gathers way. For some little time after this it will be quite sufficient for the novice to practise the art of starting and stopping the car, steering past obstacles, and driving backwards. As soon as a certain amount of confidence has been obtained—and it will be very soon in coming—the second and even third speeds may be indulged in; but it should always be borne in mind that proficiency in steering does not of necessity imply that the driver will be

capable of doing the right thing in an emergency, so for this reason it is very necessary that his early experience should be gained—whenever possible—in some place where there is little or no traffic.

During the initial stages it is as well to avoid steep hills, as these always constitute a real danger to the beginner, almost as much when ascending as descending, and unless he has thoroughly mastered the art of changing speed he may be unable to do this at the critical moment when halfway up a hill, with the result that the car may begin to run backwards, and serious trouble is almost certain to result, unless the driver is very quick with his brakes. Again, when descending a hill the beginner is very apt not to notice the speed at which he is travelling, and to fail to appreciate the fact that his brakes cannot safely be applied with the same force or effect when going downhill as when travelling at the same pace on the level, so that in this way it is quite easy to come to grief if the exigencies of road traffic make a sudden pull up imperative.

It may be as well to mention here that one of the first things a careful driver should do, after starting his car, is to test both foot and hand brakes, to see that each is in proper working condition, and capable of pulling up his car immediately if necessary; for it is quite possible for oil to have found its way to one of these brakes during the night. A driver who neglects this precaution may easily find himself depending upon useless or indifferent brakes just at the moment when he most requires them.

Although brakes should be capable of locking the wheels in the event of great emergency, the novice should remember that the less he uses the brakes

the better for his car in all respects, and especially in regard to the wear and tear of his tyres. The loss of time due to allowing the car to gradually roll up to the place where you intend to stop, in such a manner that a very slight application of the brake at the right moment is sufficient to bring the car to rest, is a very small consideration as a set-off against the heavy tyre bill which will await the man who regularly "drives on his brakes"; that is to say, who never attempts to arrest the speed of his car until he is close up to some object he wishes to avoid, or to the place where he intends to stop. An expert can tell in a moment by looking at the tyres of a car whether or not they have been driven carefully or the reverse. It must also be remembered that the use of the hand brake rather than the foot brake should be resorted to whenever possible, as this acts directly upon the road wheels and does not place any strain upon the gear.

Unfortunately, it is too often found that the hand-brake lever is placed in such a position that it is very awkward and troublesome to operate without considerable change of position on the part of the driver. All hand-brake levers should be placed accessibly and should have as short a "travel" as possible. All brakes are provided with some means by which their wear and tear may be taken up, and the novice should be very careful to see that his foot brake exerts its full power whilst the pedal is yet well clear of the footboard, and that the hand brake also fulfils its utmost duty whilst the lever is yet some distance from the end of the quadrant. Many accidents have happened, especially to touring cars, owing to

the lack of this very simple precaution and attention. Again, I have often seen drivers refrain from applying their brakes when taking a curve until they had actually begun to round it, whereas the speed of the car should be reduced in such good time that the brakes can be almost, if not quite, safely taken off when actually taking the turn, thus allowing the car to roll round the corner by its own momentum; because, if the brakes are applied when in the act of taking a corner or curve the action of the "differential" is interfered with, and not only is unfair strain put upon the gear, but skidding is almost sure to result.

With regard to changing speed there are two golden rules to be observed, namely, to do so without noise, and to change at the right moment, so as to get the best results out of your engine. When changing from a lower to a higher speed the clutch must always be withdrawn, and at the same time the accelerator pedal should be momentarily released so that the engine may not "race," while the speed lever is being pushed forward into the next notch. The right moment to raise the speed is when the driver hears that his engine is running at its maximum number of revolutions. This can only be learnt by practice and knowledge of one's particular engine.

In reducing speed from a higher to a lower gear it is hardly necessary to withdraw the clutch at all on a low-powered car, and but very little on a high-powered vehicle. The correct moment for performing this reduction of gear is so soon as one hears the engine begin to labour or slow down.

One of the greatest dangers that has to be guarded against in learning to drive is side-slip.

Almost the only preventive for this is strict caution, and to avoid placing one's self in such a position that a quick pull-up becomes necessary.

The majority of side-slips are experienced in towns on either wood or asphalt pavings. One should always, therefore, leave as much space as possible between one's car and the next vehicle in front, so that there will be time to pull up slowly and not by a sudden application of the brakes. Directly the slightest sign of side-slip is felt the clutch should be withdrawn and the car steered in the same direction in which the skid is taking place. At this juncture it is frequently a good plan to allow the clutch to go in again for about a second, as this is often enough to gather steerage way. Whenever grease is encountered the motor should be kept running as evenly as possible, and the slowing up of the car should be effected rather by closing the throttle than by disconnecting the clutch.

[The management of the motor-car on the road is more fully dealt with in another of "The Car" Publications entitled THE ART OF DRIVING A MOTOR CAR, by Lord Montagu. 1s.]

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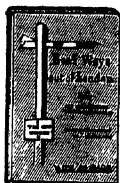
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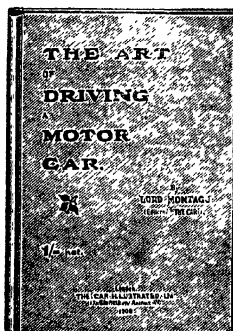
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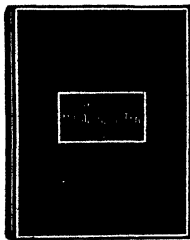
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